

TRANSMITTER MOUNTING STRUCTURE FOR TIRE CONDITION MONITORING APPARATUS

5

BACKGROUND OF THE INVENTION

The present invention relates to a transmitter mounting structure for a tire condition monitoring apparatus, and more specifically, to a transmitter mounting structure for a wireless type tire condition monitoring apparatus enabling tire conditions, such as tire air pressure, to be checked from the passenger compartment of a vehicle.

10

A transmitter for a tire air pressure monitoring apparatus is mounted on a wheel and located in a tire. A mounting structure of the transmitter includes a valve stem, a spring element, and an electronic module for measuring the air pressure of the tire and transmitting the measured air pressure. The valve stem is coupled to the spring element. The spring element has a clamp plate coupled to the electronic module. The clamp plate clamps the electronic module to the wheel. When the wheel is rotating, various forces, such as centrifugal force, act upon the electronic module. The elastic force of the spring element acts to effectively suppress or control the movement of the electronic module. Accordingly, the electronic module is pressed against a drop center of the wheel when mounted on the wheel (refer to United States Patent No. 5,956,820).

15

20

The fastening device described in United States Patent No. 5,956,820, however, cannot cope with all the cross sectional shapes of wheels. That is, there are many types of wheels with different cross sectional shapes, such as, wheels with a drop-center rim, a shallow base rim, a broad flat-base rim, and a broad deep rim. Therefore, the valve stem and the casing which houses the transmitter, and ultimately the mounting angle of the

25

electronic module, is unambiguously determined by the cross sectional shape of the wheel. As a result, in order to mount the electronic module in a state pressed against the drop center

of the wheel, the spring element and clamp plate must be in correspondence to the cross sectional shape of the wheel.

SUMMARY OF THE INVENTION

One aspect of the present invention is a mounting structure for a transmitter of a tire condition monitoring apparatus arranged in a tire of a vehicle having a wheel. The wheel including a drop center and a rim formed integrally with the drop center at a predetermined angle relative to the drop center. The mounting structure includes a valve stem attachable to the rim of the wheel for charging air into the tire. The valve stem has a basal end. The mounting structure further includes a casing connected to the valve stem to house the transmitter and a coupling fixture for coupling the casing and the valve stem. The coupling fixture includes a coupler coupled to the basal end of the valve stem, an anchor for anchoring the casing and a connection for connecting the coupler and the anchor at an angle to one another so that the coupling fixture is resilient. The angle between the coupler and the anchor is greater than the predetermined angle before the coupling fixture couples the casing and the valve stem to one another.

Another aspect of the present invention is a method of mounting a transmitter of a tire condition monitoring apparatus arranged in a tire of a vehicle having a wheel. The wheel includes a drop center and a rim formed integrally with the drop center at a predetermined angle relative to the drop center. The rim has a valve hole. The method includes preparing a valve stem for charging air into a tire, the valve stem having a basal end, preparing a casing for housing the transmitter, the casing having a projection, preparing a coupling fixture for coupling the casing and the valve stem, the coupling fixture including a coupler coupled to the basal end of the valve stem and having a coupling hole, an anchor for anchoring the casing, and a connection for connecting the coupler and the anchor at an angle to one another so that the coupling fixture is resilient, with the angle between the coupler and the anchor being greater than the predetermined angle before the coupling fixture couples the casing and the valve stem, attaching the casing to the anchor of the coupler, inserting the basal end of the

valve stem through a coupling hole of the coupling fixture to couple the basal end of the valve stem to the coupling fixture with a bushing, and attaching the valve stem to the valve hole in the rim when the projection of the casing is abutted against the drop center of the wheel by the resiliency of the coupling fixture.

- 5 Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with the objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

5 **Fig. 1** is a schematic block diagram showing the structure of a tire condition monitoring apparatus according to a preferred embodiment of the present invention;

Fig. 2 is a cross sectional view of a transmitter mounting structure for the tire condition monitoring apparatus in the preferred embodiment of the present invention;

Fig. 3 is a plan view of the transmitter of the tire condition monitoring apparatus of
10 **Fig. 2**;

Fig. 4(a) is a plan view showing a plate spring used in the mounting structure of **Fig. 2**, and **Fig. 4(b)** is a cross sectional view of the plate spring of **Fig. 4(a)**;

Fig. 5 is a perspective view showing a bracket used in the mounting structure of **Fig. 2**;

15 **Fig. 6** is a cross sectional view showing the state of a casing for the transmitter mounting structure of the tire condition monitoring apparatus when the vehicle velocity is less than a first speed; and

Fig. 7 is a cross sectional view showing the state of the casing of **Fig. 6** when the vehicle velocity is greater than or equal to a second speed.

20

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the drawings, like numerals are used for like elements throughout.

Fig. 1 is a schematic diagram of a tire condition monitoring apparatus, which includes a transmitter mounting structure according to a preferred embodiment of the present invention. As shown in **Fig. 1**, the tire condition monitoring apparatus **1** includes four transmitters **30**, each arranged in each tire **20** of a vehicle **10**, and a receiver **40** arranged in the body **11** of the vehicle **10**.

Each transmitter **30** is fixed to the interior of the corresponding tire **20**, for example, to the wheel **21** of the tire **20**. The transmitter **30** measures conditions of the tire **20**, such as the tire pressure in the corresponding tire **20**, and transmits the data including the tire pressure data obtained through the measurement in a wireless manner.

The receiver **40** is located at a predetermined position on the body **11** and operated, for example, by electric power from a vehicle battery (not shown). The receiver **40** has a receiving antenna **41**, which is connected to the receiver **40** by a cable **42**. The receiver **40** receives data transmitted from each transmitter **30** through the receiving antenna **41**. A display **50** is arranged within the visual range of the driver of the vehicle **10** in the vehicle compartment. The display **50** is connected to the receiver **40** by a cable **43**.

As shown in **Fig. 2**, a connection concavity **61** is formed along the circumferential direction at the basal end of a valve stem **60**, which is arranged in the tire **20**. A rubber grommet **62** is fitted in the connection concavity **61**. The rubber grommet **62** is pressed against the wall defining a valve hole **22** extending through the wheel **21**. A valve nut **63** is engaged with the valve stem **60** from the outer side of the wheel **21** to fasten the valve stem **60** to the wheel **21**. As a result, the rubber grommet **62** hermetically seals the tire **20**.

A plate spring (coupling fixture) **70** is connected to the basal end of the valve stem **60**. A bushing **64** is press-fitted into the basal end of the valve stem **60** to connect the valve stem

60 and the plate spring 70. A casing 80, which houses the transmitter 30, and a bracket 90 are attached to the plate spring 70. A projection 81 extends from the bottom surface of the casing 80. The resiliency of the plate spring 70 abuts the projection 81 against a drop center 23 of the wheel 21.

5 As shown in Fig. 3, side walls 64a extend from opposite sides of the bushing 64. A through hole 64b extends through the center of the bushing 64. Air is charged into the tire from the valve stem 60 and through the through hole 64b. A valve cap 65 is engaged with the distal end of the valve stem 60.

Referring to Figs. 4(a) and 4(b), the plate spring 70 is resilient and formed, for
10 example, by bending a thin metal piece until its cross section becomes U-shaped. The plate spring 70 includes a coupler 73 coupled to the basal end of the valve stem 60. A coupling hole 71 extends through the coupler 73. The plate spring 70 also includes an anchor 74, which is anchored to the casing 80, and a connection 75, which connects the coupler 73 and the anchor 74. Two anchor holes 72 extend through the anchor 74. The connection 75
15 connects the coupler 73 and the anchor 74 so that the plate spring 70 is resilient. More specifically, the connection 75 is bent so as to have a predetermined curvature R, as shown in Fig. 4(b).

As shown in Fig. 4(b), the angle θ_2 formed between the coupler 73 and the anchor 74 before the plate spring 70 is attached to the valve stem 60 is greater than the angle θ_1 formed
20 between the coupler 73 and the anchor 74 after the plate spring 70. The reason for this is to cope with the various cross sectional shapes a wheel 21 may have. For example, the plate spring 70 may be employed even when the rim angle (second predetermined angle) θ_r formed between a drop center 23 of the wheel 21 and a rim 24 of the wheel 21 is larger than angle θ_1 (first predetermined angle), as shown in Fig. 6. More specifically, before the plate
25 spring 70 is attached to the valve stem 60, the angle θ_2 formed between the coupler 73 and

the anchor 74 is set so as to be greater than the angle θ_1 and the angle θ_r .

As shown in Fig. 5, a bracket 90 is provided with two rotation regulating walls 91 for regulating the rotation of the plate spring 70. The rotation regulating walls 91 abut against the side walls 64a of the bushing 64 when the valve stem 60 is inserted through the valve hole 22. As shown in Fig. 3, the two rotation regulating walls 91 are formed so as to sandwich the side walls 64a of the bushing 64. Two anchor holes 92 extend through the bracket 90. The anchor holes 92 correspond to the two anchor holes 72 of the plate spring 70.

As shown in Fig. 2, two protrusions 82 extend from the top surface of the casing 80. The protrusions 82 project through the anchor holes 92 of the bracket 90 and the anchor holes 72 of the plate spring 70. The projected part of each protrusion 82 is heated and deformed into a rivet shape. This fixes the casing 80 to the plate spring 70 and the bracket 90.

A method for arranging the valve stem 60 in the valve hole 22 of the wheel 21 will now be described.

As shown in Fig. 6, when the casing 80 is fixed to the plate spring 70 and the bracket 90, the bushing 64 is inserted through the coupling hole 71 of the plate spring 70. Then, the bushing 64 is press fitted to the basal end of the valve stem 60 to connect the basal end of the valve stem 60 to the plate spring 70.

Subsequently, in a state in which the valve nut 63 and the cap 65 are removed, the valve stem 60 is inserted through the valve hole 22 from the inner side of the wheel 21. Then, the valve nut 63 is threadably engaged with the valve stem 60 from the outer side of the wheel 21 to attach the valve stem 60 to the wheel 21. At this time, the plate spring 70, which is coupled to the basal end of the valve stem 60, tends to rotate in the turning direction of the valve nut 63 when threading the valve nut 63 on to the valve stem 60. However, as shown in Fig. 3, the side walls 64a of the bushing 64, which is pressed fitted into the basal

end of the valve stem **60**, abuts against the rotation regulating walls **91** of the bracket **90**.

Further, as shown in Fig. 6, the bracket **90** is fixed to the plate spring **70** by the pair of protrusions **82** of the casing **80**.

The projection **81** extending from the bottom surface of the casing **80** is abutted
5 against the drop center of the wheel **21** by the resiliency of the plate spring **70**. Therefore,
the side walls **64a** of the bushing **64** abuts against the rotation regulating walls **91** and
regulates the rotation of the plate spring **70** even when the plate spring **70** tends to rotate in
the rotation direction of the valve nut **63** when screwing the valve nut **63** on to the valve stem
60. As a result, the plate spring **70** does not rotate in the rotation direction of the valve nut
10 **63** when the valve nut **63** is threaded on to the valve stem **60**. Accordingly, the valve stem
60 is attached to the wheel **21** in a state in which the projection **81** of the casing **80** is abutted
against the drop center **23** of the wheel **21**.

Centrifugal force acts on the casing **80** when the vehicle **10** is moving. The
centrifugal force increases in proportion to the velocity of the vehicle **10**. Therefore, when
15 the velocity of the vehicle **10** reaches a first velocity (for example, 40 km/h), the centrifugal
force becomes greater than the resiliency of the plate spring **70**. As a result, when the
vehicle **10** is moving at the first velocity or faster, the projection **81** of the casing **80** moves
away from the drop center **23** of the wheel **21**.

When the vehicle **10** reaches a second velocity (for example, 80 km/h), which is
20 greater than the first speed, distal portions **91a** of the rotation regulating walls **91** abut against
the coupler **73** of the plate spring **70**, as shown in Fig. 7. This restricts further movement of
the casing **80** from the drop center **23** of the wheel **21** even when the velocity becomes
greater than the second speed. As a result, the resiliency of the plate spring **70** is
maintained. When the velocity of the vehicle **10** becomes less than the first velocity, the
25 projection **81** of the casing **80** abuts against the drop center **23** of the wheel **21** again, as

shown in Fig. 6.

When the vehicle 10 is not moving or when changing the tire 20, the projection 81 of the casing 80 is abutted against the drop center 23 of the wheel 21. Thus, when changing the tire 20, the bead of the tire 20 does not hit the bracket 90. This prevents the casing 80, which houses the transmitter 30, from being damaged. When the vehicle is moving at a velocity that is greater than or equal to the first velocity, the projection 81 of the casing 80 is moved away from the drop center 23 of the wheel 21. This lessens the influence of the wheel 21 on radio waves transmitted from the transmitter 30. That is, since the casing 80 which houses the transmitter 30 becomes more distant from the wheel 21, which is generally formed of metal, the radio waves transmitted from the transmitter 30 are less affected by the wheel 21. Thus, the reception sensitivity of the receiver 40 improves when the vehicle is moving at a velocity that is greater than or equal to the first speed. Accordingly, the receipt of data transmitted from the transmitter 30 by the receiver 40 through the receiving antenna 41 is ensured.

The transmitter mounting structure for a tire condition monitoring apparatus of the present embodiment has the advantages described below.

(1) The angle θ_2 (refer to Fig. 4(b)) formed by the coupler 73 and the anchor 74 of the plate spring 70 before the plate spring 70 is attached to the valve stem 60 is set so as to be greater than the maximum rim angle θ_r (refer to Fig. 6) formed between the drop center 23 of the wheel 21 and the rim 24 of the wheel 21. Therefore, when the valve stem 60 coupled to the plate spring 70 is attached to the wheel 21, the projection 81 of the casing 80 is abutted against the drop center 23 of the wheel 21. Accordingly, the transmitter 30 may be attached to the wheel 21 regardless of the cross sectional shape of the wheel 21. Thus, when the casing 80 is abutted against the drop center 23 of the wheel 21, the valve stem 60 is attached to the wheel 21 regardless of the cross sectional shape of the wheel 21.

(2) The two rotation regulating walls 91 extending from the bracket 90 abut against the side walls 64a of the bushing 64 when the valve stem 60 is arranged in the valve hole 22 of the wheel 21 to regulate the rotation of the plate spring 70. The side walls 64a of the bushing 64 are located between the two rotation regulating walls 91 to abut against the rotation regulating walls 91. Therefore, the rotation of the plate spring 70 is regulated even when the plate spring 70 tends to rotate in the rotation direction of the valve nut 63 when threading on the valve nut 63 on the valve stem 60. As a result, the plate spring 70 does not rotate in the rotation direction of the valve nut 63 when the valve nut 63 is threaded on to the valve stem 60. Accordingly, the abutment of the projection 81 of the casing 80 against the drop center 23 of the wheel 21 enables the attachment of the valve stem 60.

(3) When the velocity of the vehicle 10 attains a second velocity (for example, 80 km/h) greater than the first velocity (for example, 40 km/h), the distal portions 91a of the rotation regulating walls 91 abut against the coupler 73 of the plate spring 70, as shown in Fig. 7. Therefore, the casing 80 does not separate from the drop center 23 of the wheel 21 even when the vehicle moves at a velocity greater than the second speed. As a result, the elastic return force of the plate spring 70 is maintained. When the velocity of the vehicle 10 decreases to below the first speed, the projection 81 of the casing 80 abuts the drop center 23 of the wheel 21.

(4) Since the electronic module (casing 80) is arranged in a state pressed against the drop center of the wheel 21, a spring element and a clamp plate conforming to the cross sectional shape of a wheel, as described in United States Patent No. 5,956,820, are unnecessary. This reduces the number of parts and facilitates the management of such parts when manufacturing the device. Accordingly, parts are assembled together more efficiently and manufacturing efficiency is improved.

It should be apparent to those skilled in the art that the present invention may be

embodied in many other specific forms without departing from the spirit or scope of the invention. Particularly, it should be understood that the invention may be embodied in the following forms.

5 The relationship between the bushing **64**, which is provided with the side walls **64a** and press fitted to the basal end of the valve stem **60**, and the regulating walls **91**, which extend from the bracket **90**, may be reversed. That is, the rotation regulating walls may be formed on the bushing **64**, and side walls corresponding to the rotation regulating walls may be formed on the bracket **90**.

10 The present invention may be embodied in any type of vehicle that uses a tire **20**, such as a four-wheeled vehicle, a two-wheeled vehicle, a bus, or a truck.

The present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.